Natural Remanent Magnetisation of Selected Rock Samples from the Finnish Bedrock: Implications for Structural Modelling of Magnetic Data

Role of Natural Remanent Magnetisation in Magnetic Modelling

Magnetic minerals in rocks retain permanent natural remanent magnetisation (NRM). When the magnitude of the NRM exceeds the magnitude of induced magnetisation (the component induced by the Earth's magnetic field due to the rock's magnetic susceptibility k), the NRM plays a significant role in the formation of magnetic anomaly patterns observed in magnetic surveys. The ratio of remanent to induced magnetisation is expressed by the Königsberger ratio (Q). With Q > 1, the NRM intensity exceeds that of the induced magnetisation.

The direction of NRM (inclination I and declination D) is in many cases not aligned to the current Earth's field, and in case the direction of high-intensity NRM cannot be determined, modelling of magnetic anomalies becomes precarious. Reliable determination of NRM parameters requires adequate oriented sampling and laboratory measurements.

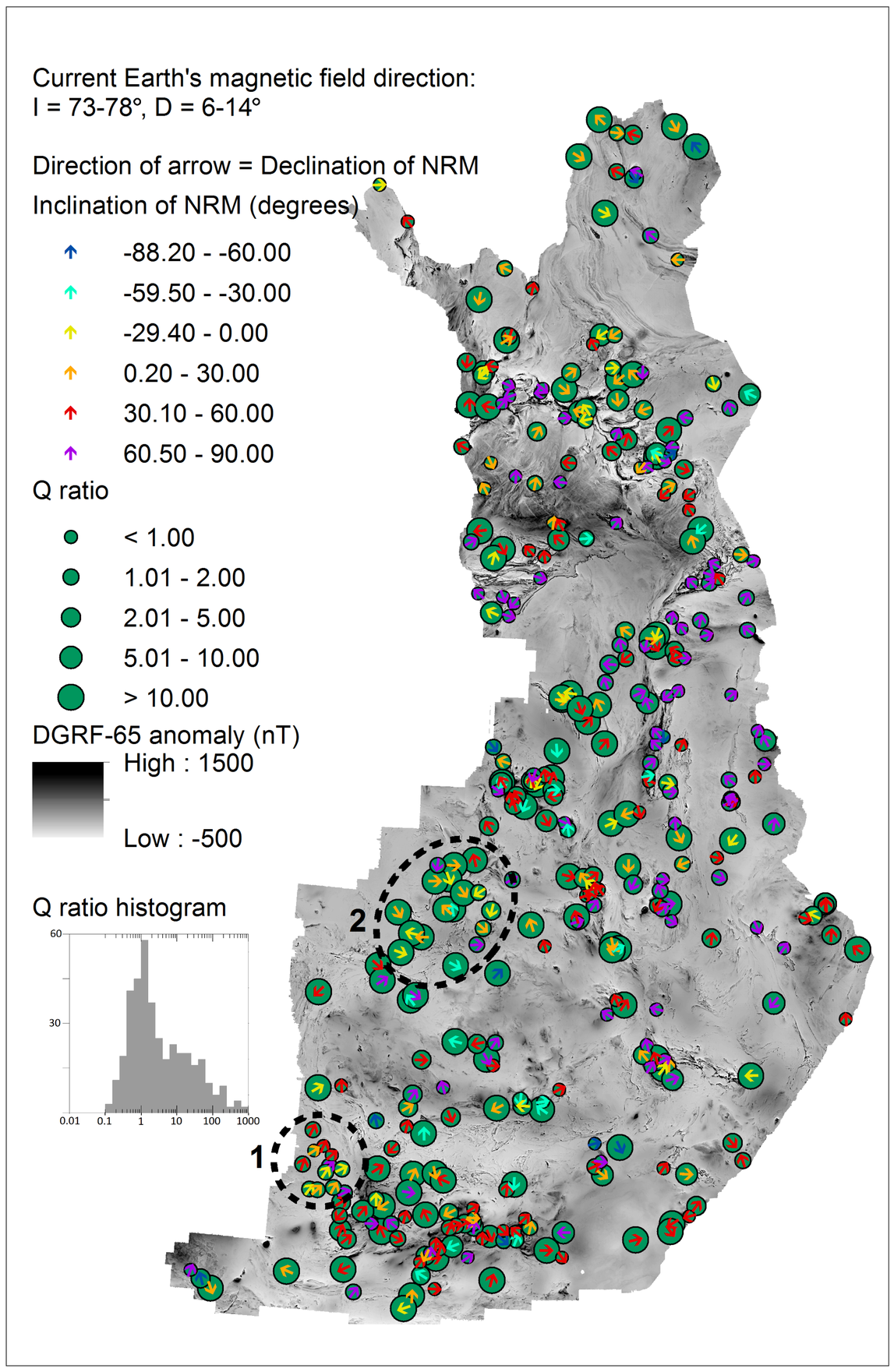

Figure 1. The NRM directions and Q ratios for the RGDB samples with intensity of NRM ≥ 1 A/m. Annotated regions: 1 = Satakunta, 2 = Pohjanmaa. Background map: GTK airborne magnetic data.

NRM Values in the Rock Geochemical Database

The Rock Geochemical Database (RGDB) (Rasilainen et al. 2007) contains determinations of magnetic susceptibilities and NRM intensities and directions. The precision of the NRM values is estimated to be reliable only for samples with high intensities (NRM ≥ 1 A/m; 357 samples). The NRM directions and the related Q values and their histogram from these RGDB data are presented in Figure 1.

Modelling example

We present a modelling case of aeromagnetic data from south-western Finland to emphasise the importance of acquiring comprehensive petrophysical data in case of high intensity of NRM. On the modelling profile (Fig. 2), there are two petrophysical samples, one originating from the RGDB and one from the GTK National Petrophysical Database (NPDB) with unknown direction of NRM. The total magnetisations resulting from the samples are not equal, which already demonstrates the need for additional sampling in order to more completely determine the magnetic properties throughout the formation. However, based on the Q values it is obvious that the anomalies cannot be explained with the observed magnetic susceptibilities only.

Assuming the NRM aligns to the current Earth's field and using approximately the susceptibility and Q values from the NPDB, the modelling produces a source body significantly different from the model produced with the RGDB values with known direction of NRM (Fig. 3). Further petrophysical or geological constraints are needed for assessing which one of the models is more realistic.

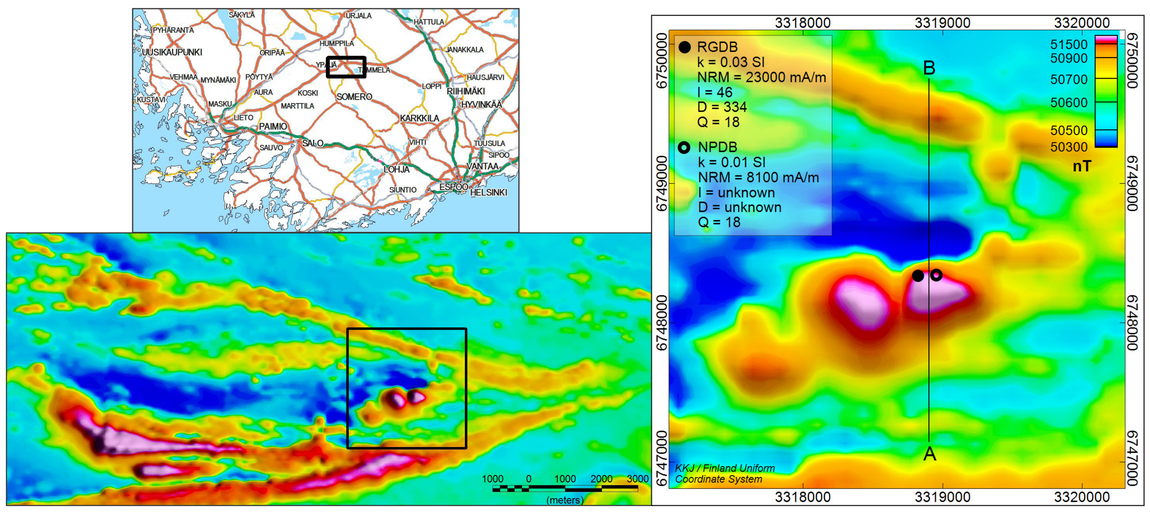

Figure 2. Location of the modelling case region with the modelling profile A-B and petrophysical sample locations indicated in the detail map (on the right).

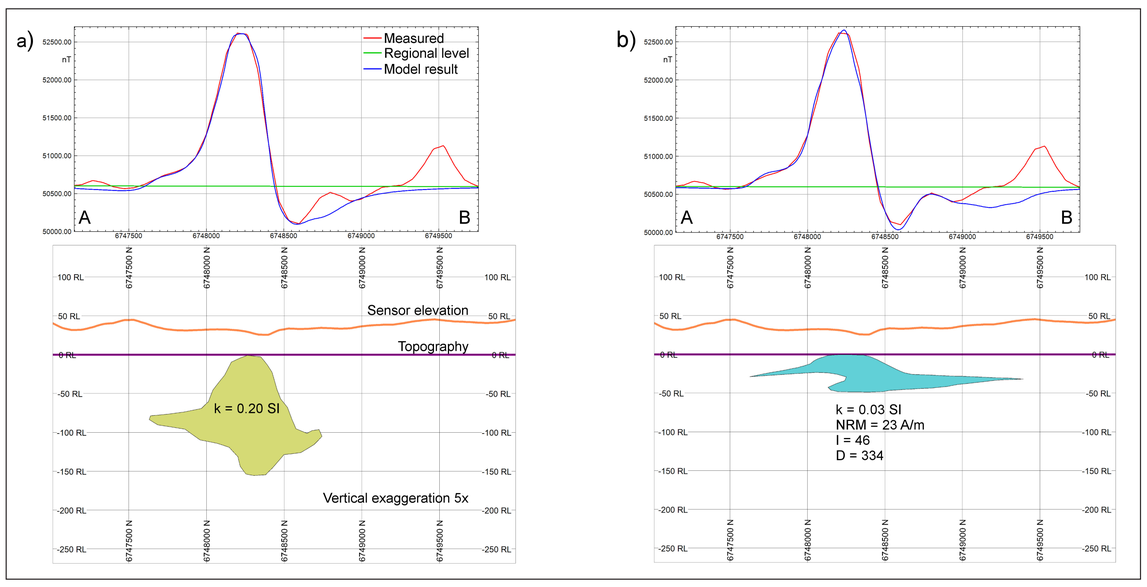

Figure 3. The modelling results for the profile A-B: a) magnetisation of the source body aligned to the direction of the current field (k=0.2 SI could also be written as k=0.01 SI and Q=19, values corresponding approximately to measurements in the NPDB) and b) magnetic susceptibility and remanent magnetisation of the source body corresponding to the RGDB dataset values.

References

Rasilainen, K., Lahtinen, R., Bornhurst, T. J., 2007. The Rock Geochemical Database of Finland Manual. Geological Survey of Finland, Report of Investigation 164, 38 pages.

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